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[54] PROJECT ESTIMATOR

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[51] Int. Cl.<sup>6</sup> ..... G06F 17/00[52] U.S. Cl. .... 395/21; 395/22; 395/50;  
395/60; 395/61[58] Field of Search ..... 364/401, 468,  
364/402, 431.01, 281, 152; 395/650, 22,  
20, 21, 11

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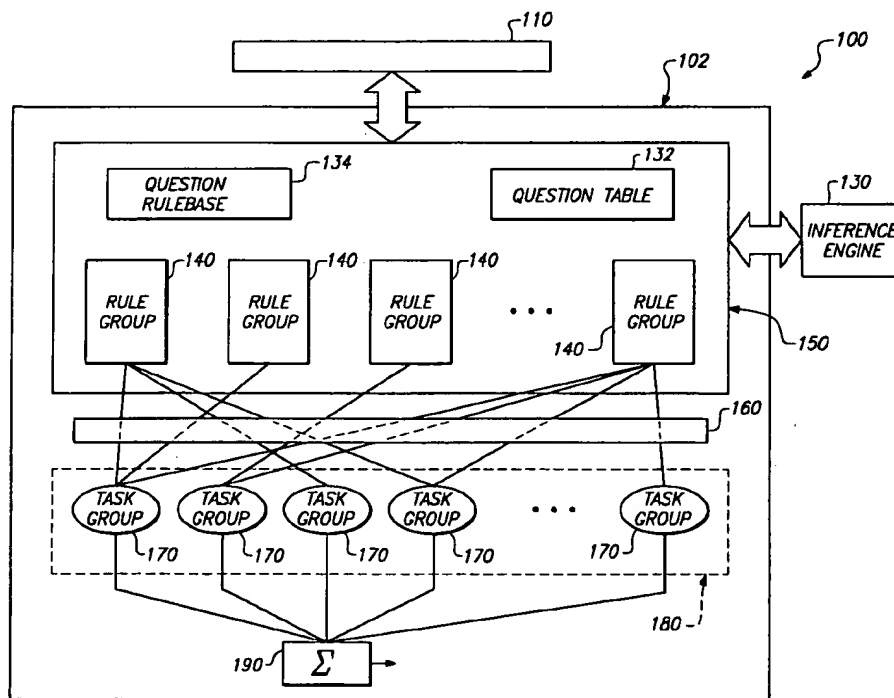
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Attorney, Agent, or Firm—Fenwick & West LLP

## [57] ABSTRACT

A system for estimating the effort necessary to complete a project comprises a rule-based expert system including groups of related estimation rules (rule groups) and a question table, a neural network, the neurodes of which represent groups of the detailed tasks (task groups), a rule indirection module for coupling the outputs of the rule-based expert system to selected neurodes, and an inference engine for implementing the rules of the expert system. The expert system, neural network, and rule indirection module are organized as an advisor module, which communicates information between an advisor interface and the question table. Each rule group represents a quantifiable feature of the specific client/server implementation, such as its size or fault tolerance requirements. The inference engine applies the rule groups to user provided data, and each rule group generates an effort factor (EF) that provides a measure of the associated feature's potential impact on the task groups. The rule indirection module couples each effort factor to selected task group neurodes according to influence factors (IF), which represent the correlation between the feature characterized by the rule group and the selected task groups. The influence factors are initially estimated as part of the expert system but may be further optimized by training the estimator using actual measured efforts and efforts estimated by the present invention.

8 Claims, 5 Drawing Sheets



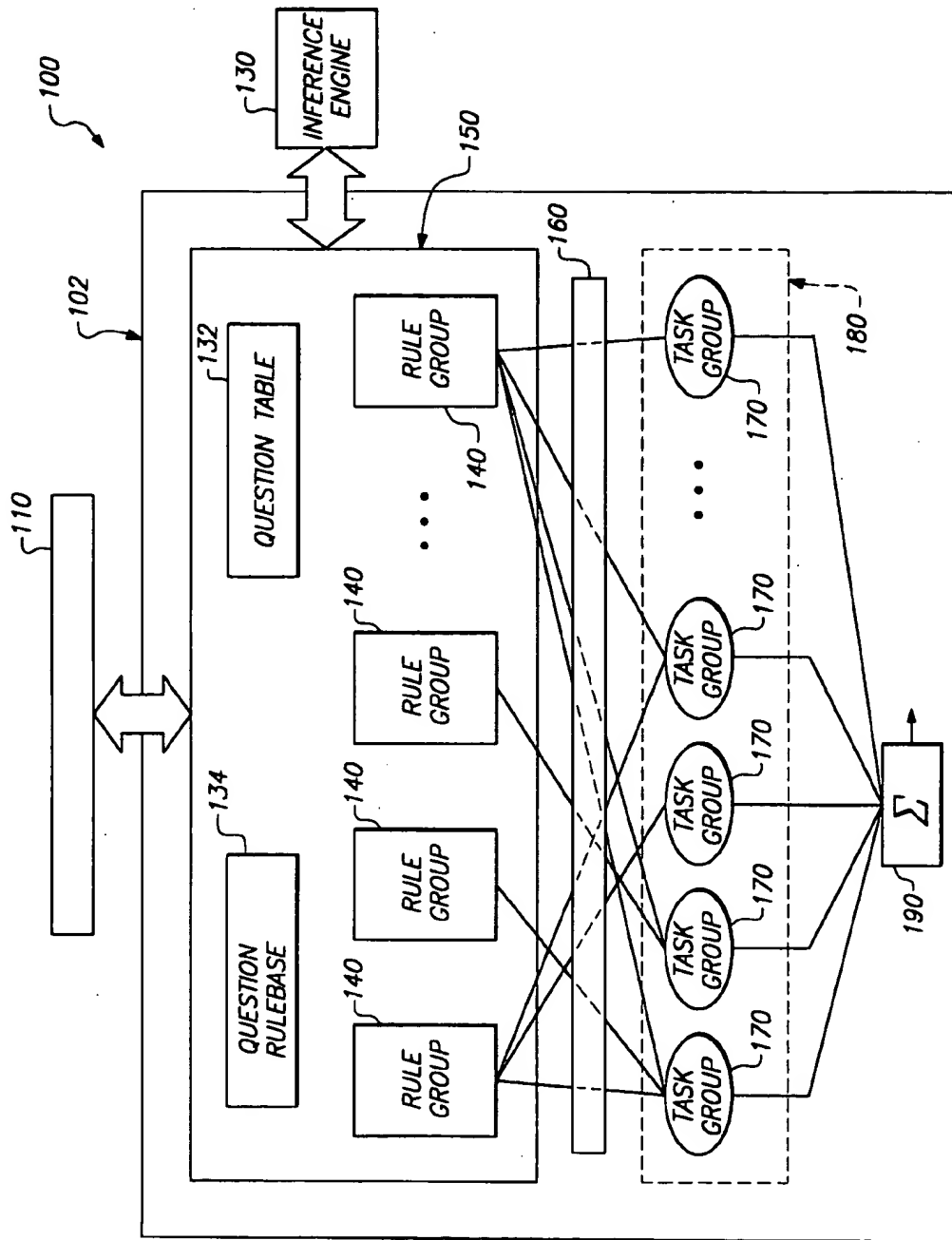


FIG. 1

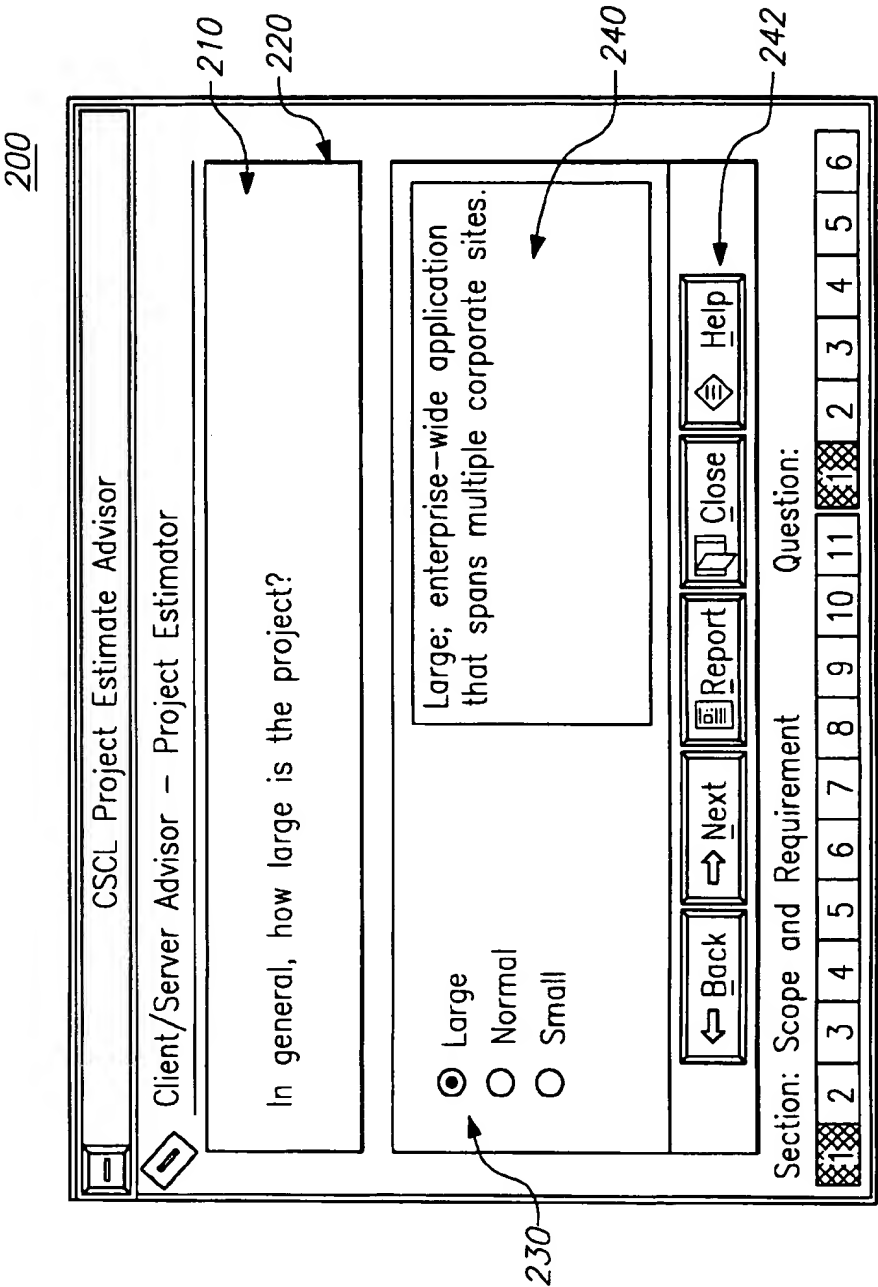
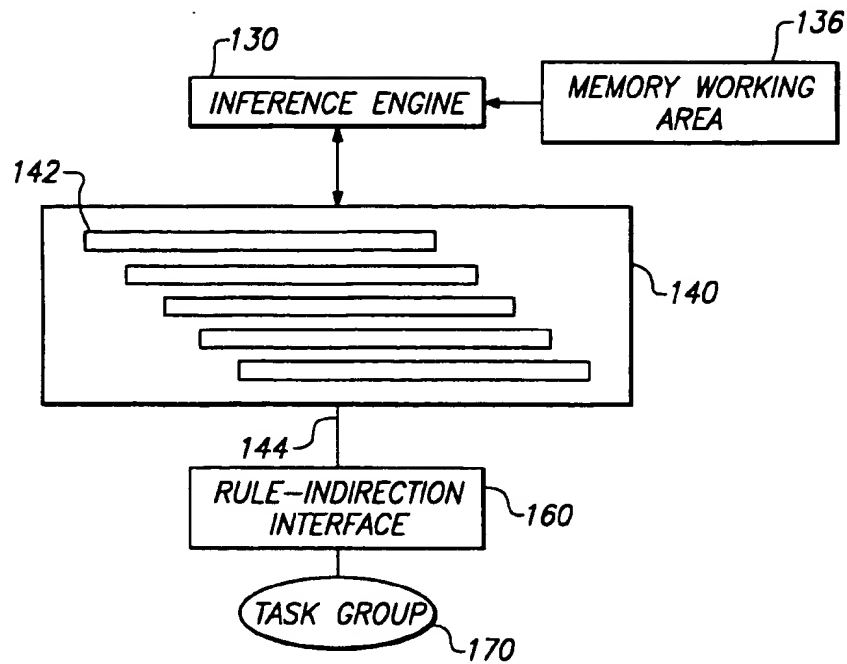
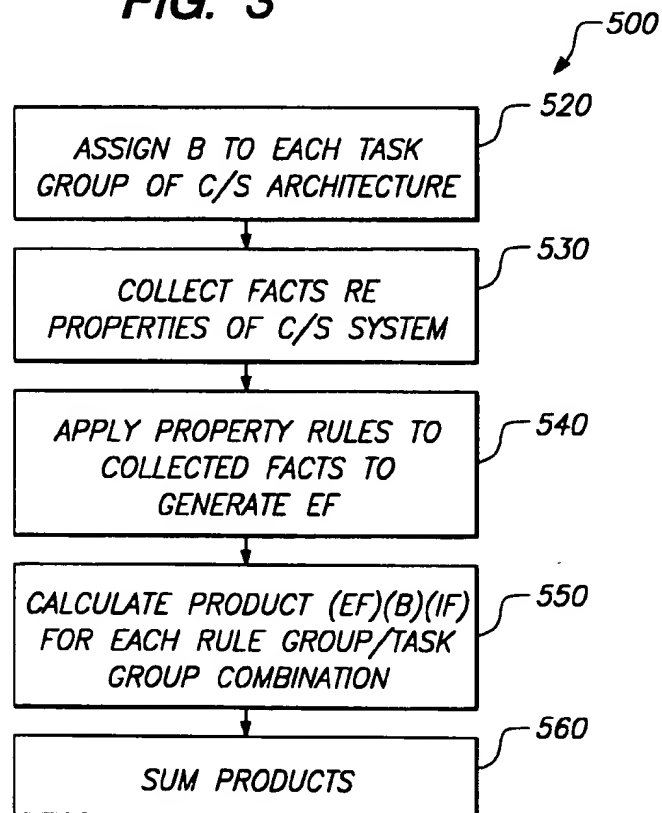


FIG. 2

**FIG. 3****FIG. 5**

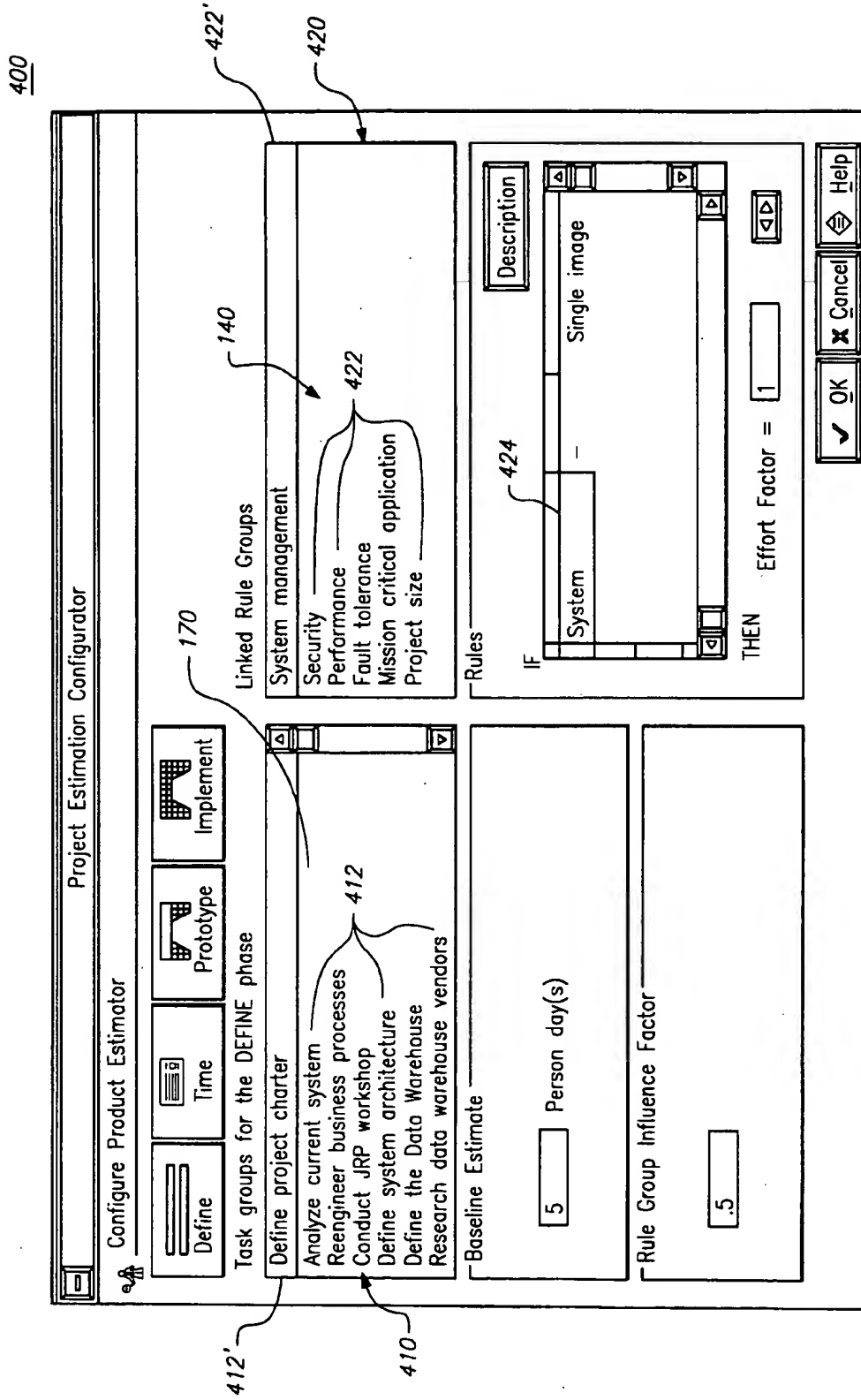


FIG. 4

600

620

622

Project Estimate Reconciliation

Actual ☒ Estimated ☐

	Actual	Estimated
Define	100%	1.7 person month
Time	0%	1 person month
Prototype	0%	1 person month
Implement	0%	1 person month

Task groups for the DEFINE phase:

612

Define project charter

Analyze current system

Reengineer business processes

Conduct JRP workshop

Define system architecture

Define the Data Warehouse

Research data warehouse vendors

Task Group Effort:

1 person days

Percentage of this phase:

4%

Close Help

FIG. 6

## PROJECT ESTIMATOR

## RELATED PATENT APPLICATIONS

This patent application is related to co-pending U.S. patent application Ser. No. 08/609,398 entitled "Knowledge Base Advisor", assigned to the same assignee identified herein, and filed on even date herewith.

## BACKGROUND OF THE INVENTION

## 1. Technical Field

This invention relates to systems and methods for estimating the amount of effort, i.e. person hours, person months, etc., necessary to complete a project, and in particular, to systems and methods that employ artificial intelligence techniques for estimating the effort necessary to design and implement client/server computer systems.

## 2. Background Art

In order to properly plan and budget for any significant project, business managers must make some estimate of the person hours that will be required to complete the project. This allows managers to set staffing levels and develop budgets that are consistent with their companies' strategic, marketing, and financial plans. Currently available methods for estimating the person hours necessary to complete a project are not very accurate. They work best with projects that can be completed with a small number of well defined tasks and their accuracy decreases as the complexity of the projects increase.

The computer industry in general and the software industry in particular are rife with examples of products whose release dates have been rescheduled multiple times. Large scale software development projects, such as new operating system releases, are notorious for missing successive release dates and are among the most visible examples of the problems with current project estimation methods.

Client server computer systems are another example of computer development projects that are notoriously difficult to plan, schedule, and budget. Many companies are very interested in acquiring client server computer systems because the flexibility of client/server systems allows them to be customized to each company's business needs. However, this flexibility also contributes to the complexity of designing and implementing client/server systems.

Some methods are available for estimating the effort required to complete large scale projects such as designing and implementing client/server systems, but none of these provide the accuracy system managers and planners require. One conventional method, function point analysis, requires the project manager to estimate the number of software features, such as screens, interfaces, and the like, that will be needed for a software system and the complexity of these features. The time necessary to develop the software for each feature is adjusted to reflect the feature's complexity and the project effort is taken as the sum of the development time for each feature in the software.

A major flaw in the function point analysis approach is that it is nearly impossible to estimate either the number of features in a software project or their complexity without first developing a detailed plan of the software. Such detailed project plans are usually not generated until a budget has been approved for the project. As a result, estimated number of screens and their complexity are rough approximations at best, and not the basis for reliable estimates of the number of person hours required for a project.

There is thus a need for a reliable system and method for estimating the effort necessary to complete complex software projects, such as the implementation of client/server systems.

## SUMMARY OF THE INVENTION

The present invention is a system and method for accurately estimating the person hours necessary to implement a client/server computer system from a set of detailed but generic tasks specified for a client/server system having a selected architecture. The system and method of the present invention customize the generic tasks to reflect user specified properties of the system, such as the development environment, the major applications, size, fault tolerance, and the resources/expertise of the organization implementing the system.

In accordance with the present invention, an advisor module comprises a rule-based expert system, a neural network, the neurodes of which represent groups of the detailed tasks (task groups), and a rule indirection module for coupling the outputs of the rule-based expert system to selected neurodes. The strength of the coupling is determined in part by training the neural network. The advisor module controls data coupling between an advisor interface and the rule based expert system, which further comprises groups of related estimation rules (rule groups) and a question table. An inference engine applies the rules to data provided by a user through the advisor interface. Each rule group represents a quantifiable feature of the specific client/server implementation, such as its size or fault tolerance requirements. In combination with the inference engine, each rule group produces an effort factor (EF) that provides a measure of the associated feature's potential impact on the task groups.

The rule indirection module couples each effort factor to selected task group neurodes according to influence factors (IF), which represent the correlation between the feature characterized by the rule group and the selected task groups. In effect, the rule-indirection module IFs scale EF, the potential impact of a rule group on the implementation, to reflect the correlation between the task group and the feature of the client/server implementation represented by the rule group. The influence factors are initially estimated as part of the expert system but may be further optimized by training the project estimator using actual measured efforts and efforts estimated by the present invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the project estimator in accordance with the present invention.

FIG. 2 is a display of advisor interface module from the system of FIG. 1.

FIG. 3 is a more detailed block diagram showing the interaction between the advisor interface module and a rule group.

FIG. 4 is a view of a configuration (rule indirection) module, showing the coupling between task group neurodes and rule groups.

FIG. 5 is a flow chart of a method for estimating the effort required to complete a project in accordance with the present invention.

FIG. 6 is a view of a reconciliation module, for training the neural network of the system of FIG. 1.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention rationalizes methods for estimating the effort necessary to implement a client/server computer system by explicitly taking into account the objective set of

tasks necessary to construct a client/server system with a given architecture and the implementation-specific features of the system, such as its size, criticality to the company, required fault tolerance, and company resources. By carefully defining the task groups associated with construction of a given client/server system architecture, accurate baseline efforts may be attributed to each task group. The system and method of the present invention then customize these task groups to reflect the implementation details of a specific project, such as the company's development environment, resources, and planned uses of the system.

The task groups employed in the present invention may be determined in a number of different ways. For example, task groups necessary to construct a client/server system having a specified architecture may be determined from discussions with system integrators who have installed such client/server systems. The scope of this undertaking is made manageable by hierarchical nature of the planning process. For example, task groups are typically generated for major components of the client server system for each phase of the installation (defining, planning, prototyping, implementing). The tasks that make up each task group are then more easily defined and the effort involved for each task can be more accurately estimated.

In the preferred embodiment of the present invention, the task groups are determined using a knowledge base advisor system, described in co-pending U.S. patent application Ser. No. 08/609,398, incorporated by reference herein. This system uses a rule based expert system to determine a client/server architecture suitable for a user, based upon the user's responses to questions provided by an advisor interface. In conjunction with architecture selection process, the system also selects task groups necessary to construct a client/server system having the identified architecture from a super set of task groups that is stored in the knowledge base of the expert system. Task groups relevant for construction of a client/server architecture are selected from a superset of task groups in conjunction with an architecture selection advisor and a task advisor. Appendix B includes the superset of tasks and component sub-tasks from which task groups for a specific client server architecture project are selected.

Provided the component tasks of a task group are well-defined, the baseline efforts for each task group may be readily determined for a specified set of conditions, including skill levels, resources, fault tolerance, and the like. Each of these factors will vary from the specified level depending on different, quantifiable aspects of the implementation. The present invention identifies these factors and their complex interactions using a rule based expert system.

Referring first to FIG. 1, there is shown a block diagram of a project estimator 100 in accordance with the present invention. Project estimator 100 is organized as an advisor interface 110, an inference engine 130, and an advisor module 102 comprising, a ruled based expert system 150, a rule-indirection interface 160, a neural network 180, and a summer 190. Expert system 150 further comprises a question table 132 and a plurality of rule groups 140. Responses to questions are stored in an area of working memory (not shown) associated with question table 132 and accessible to inference engine 130. Neural network 180 comprises a plurality of task group neurodes 170, each of which corresponds to a set of well-defined tasks (not shown).

Advisor module 102 couples questions from question table 132 to advisor interface 110, displays them to a user as shown in FIG. 2, and stores the user's responses in working memory accessible to inference engine 130. In one embodiment of the invention, a question rulebase 134 is used by advisor module 102 to display to the user, through the advisor interface 110, questions selected on the basis of the users previous responses. A more detailed discussion of such "intelligent questioning" is provided in the Knowledge Base Advisor application, incorporated by reference herein.

Advisor interface 110, advisor module 102, and inference engine 130 are implemented on any of a number of currently available processor platforms. In a preferred embodiment of the present invention, advisor interface 110, advisor module 102, and inference engine 130 are implemented on a platform having processing power at least equivalent to that of an Intel processor (386 or higher) running the Windows operating system (3.1 or higher).

Referring now to FIG. 2, there is shown a screen 200 produced by advisor module 102 at interface 110. The user is presented with a question 210 in window 220 and possible responses 230 appear below window 210 on the left side of screen 200. As each possible response 230 is highlighted, an explanation 240 of its significance is shown on the right of screen 200, allowing the user to choose a well-informed response. Icons 242 along the bottom of the screen allow the user to view earlier or later questions, request help, or trigger the inference engine 130 to begin processing the answers.

Table 1 includes a sample of questions 210 presented to the user by advisor interface 110, possible responses 230 and explanations 240 of how each response will be interpreted by project 100. Note that the questions estimator 210 relate to quantifiable features of a client/server system such as its size, required level of fault tolerance, required performance level, and module sources. These features, which vary for each implementation of a given client/server architecture, must be considered in order to accurately estimate the effort necessary to complete the client/server installation.

TABLE 1

QUESTION	RESPONSES (Explanation)
In general, how large is the project?	<u>Large</u> (enterprise-wide application, spans multiple corporate sites.) <u>Normal</u> (corporate-wide application used by multiple departments.) <u>Small</u> (workgroup/departmental application used by a small number of people.)
Is the application going to replace a mission-critical or line-of-business process?	<u>Yes</u> <u>No</u> <u>Partially</u> (The system will have an impact on or replace some functionality of an existing mission-critical application.)
What are your application's fault-tolerance requirements?	<u>Highest availability</u> (The system must always be on line.) <u>High availability</u> (Only a few hours of down time per year) <u>Normal availability</u> (If the system fails, it must be brought back up with the current day's data within a predefined period of time.)



TABLE 1-continued

QUESTION	RESPONSES (Explanation)
What are your application's performance requirements?	<u>High</u> (Response must be immediate, no matter how many concurrent users are logged in.) <u>Normal</u> (System response must be within acceptable normal limits most of the time.)
What are your application's security requirements?	<u>Maximum</u> (Security is paramount. Information protected via data encryption.) <u>High</u> (Security is critical. Sensitive information must be protected via login, network and database security.) <u>Normal</u> (Security is important but not critical. Login provides generalized access to the entire system.) <u>Unsecured</u> (The system does not need security.)
What are your system management requirements?	<u>Single image</u> (The entire system must be able to be managed as if it is a single computer. If necessary, performance can be traded for ease of management.) <u>High</u> (The system can be managed easily and autonomously even for remote locations. However, performance consideration should come before ease of management.) <u>Normal</u> (The system is manageable by a staff of trained administrators.)
What percentage of the GUI modules will be drawn from either an object repository or from an existing application?	<u>75-100%</u> (All development in-house uses extensive object-oriented development methodologies and standardized reusable code components.) <u>50-75%</u> (There is an extensive repository of reusable code components in-house that is utilized by the majority of the development staff.) <u>25-50%</u> (There is an existing repository of reusable code components that are utilized by various developers.) <u>Less than 25%</u> (Some development teams have created their own code repositories, but standardized coding procedures and reusability standards are not employed in the organization.)
What percentage of the complex business processing modules will be drawn from either an object repository or from an existing application?	<u>75-100%</u> <u>50-75%</u> <u>25-50%</u> <u>Less than 25%</u>
What percentage of the database transaction modules will be drawn from either an object repository or from an existing application?	<u>75-100%</u> <u>50-75%</u> <u>25-50%</u> <u>Less than 25%</u>
What percentage of the new database schema can be derived from an existing database?	<u>75-100%</u> (The new application's database schema will be derived primarily from an existing database system.) <u>50-75%</u> (A large portion of the new application's database schema can be derived from an existing database system.) <u>25-50%</u> (Some of the new application's database schema can be derived from an existing database system but the majority will have to be created for this application.) <u>Less than 25%</u> (Most of the new application's database schema will be created with the development of this system.)
How stable are the critical software components such as the operating system, communications, and database servers?	<u>Extremely stable</u> (All components of the system have been thoroughly tested and successfully implemented in a number of production environments.) <u>Moderately stable</u> (Most components of the system have been tested and similar systems have been successfully implemented in the past.) <u>Unstable</u> (Little or no components of the system have been tested and/or the system will be implemented in a new or untried technology.)
How stable is the application development environment, including software tools and utilities?	<u>Extremely stable</u> (The application development tools and utilities have been used successfully on numerous projects.) <u>Moderately stable</u> (The application development tools have been used on a number of projects. The development staff is comfortable with the existing tools and proficient in their use.) <u>Unstable</u> (The application development environment for this project will be using new or untried development tools.)
How stable is the hardware technology employed in the C/S architecture such as the server, network, and communication links?	<u>Extremely stable</u> (many applications using similar hardware have been developed and successfully deployed using the existing C/S architecture.) <u>Moderately stable</u> (The proposed technology has been used successfully by other organizations, but is new to the developers of this system.) <u>Unstable</u> (The proposed application will be using relatively new or untried hardware that none of the developers of the system have worked with before.)

Once advisor interface 110 has asked all relevant questions of the user, inference engine 130 applies each rule group 140 to the responses accumulated in response memory working area 136 to generate an effort factor EF for each rule group 140. Rule groups 140 track the different questions asked by advisor interface 110, although there is not necessarily a one to one correspondence. For example, EFs for rule groups 140 relating to system criticality and GUI complexity are determined from decision tables (matrices) of user answers to selected questions. Examples of specific

rule groups 140 and their corresponding EFs are discussed in greater detail below.

Referring now to FIG. 3, there is shown a block diagram of a rule group 140 and its interactions with inference engine 130 and rule-indirection interface 160. In general, rule group 140 comprises a plurality of related rules 142 that combine to produce the single output EF. For example, in the preferred embodiment a project size rule group 140 comprises three rules 142 that are selectively fired to select an EF value based on the users response to the project size question.

TABLE 2

```

[DefineBeginRuleGroup]
RuleGroupID = 10
RuleGroupName = "Project size factor"
Description = "Project size factor"
;
[DefineRule]
RuleName = "Project size - Large"
Priority = 100
Description = ""
IF
    [Project size] = "Large"
THEN
    [#Effort_level] = 3
;
[DefineRule]
RuleName = "Project size - Normal"
Priority = 100
Description = ""
IF
    [Project size] = "Normal"
THEN
    [#Effort_level] = 2
;
[DefineRule]
RuleName = "Project size - Small"
Priority = 100
Description = ""
IF
    [Project size] = "Small"
THEN
    [#Effort_level] = 1
[DefineEndRuleGroup]

```

The structure and operation of a "project size" rule group 140 are indicated by Table 2. "Project size" is a simple, single parameter rule group 140 that generates one of three EF values as its output, depending on whether the user characterizes the project as large (enterprise wide application spanning multiple corporate sites), normal (corporate wide, multiple departments), or small (single department system used by a small number of people).

Referring now to Table 3, there is shown the definition of "system criticality" rule group 140. As noted above, in the preferred embodiment of the invention the "system criticality" EF is generated by a matrix function (decision table) of user responses to various other questions displayed by advisor interface 110.

TABLE 3

```

[DefineBeginRuleGroup]
RuleGroupID = 20
RuleGroupName = "System criticality factor"
Description = "System criticality factor"
;
[DefineRule]
RuleName = "System criticality"
Priority = 100
Description = ""
THEN
    [#Effort_level] = "@matrix('System
criticality', 'Mission critical application', 'Fault
tolerance', 'Performance', 'Security', 'System management')"
```

The EF generated by "system criticality factor" rule group 140 is determined from a decision table based on the user's answers to five other questions, labeled "mission critical application", "fault tolerance", "performance", "security", and "system management". The decision table, indicated by the operator, @matrix, is shown in Table 4.

TABLE 4

```

[DefineMatrix]
MatrixID = 10
MatrixName = "System criticality"
MatrixCol = 5
Description = "System criticality"
Default = 1
#"Mission critical application", "Fault
tolerance", "Performance", "Security", "System management"
10 Data = 3 "Yes", "*", "*", "*", "*"
Data = 3 "Partially", "*", "*", maximum, single image
Data = 3 "Partially", "*", High, "*", Single image
Data = 3 "Partially", "*", High, Maximum, "*"
Data = 3 "Partially", 'Highest availability', "*", "*", Single image
Data = 3 "Partially", 'Highest availability', "*", maximum, "*"
15 Data = 3 "Partially", 'Highest availability', High, "*", "*"
Data = 3 "No", "*", High, Maximum, Single image
Data = 3 "No", 'Highest availability', "*", Maximum, Single image
Data = 3 "No", 'Highest availability', High, "*", Single image
Data = 3 "No", 'Highest availability', High, Maximum, "*"
Data = 2 "No", "*", "*", Maximum, Single image
20 Data = 2 "No", "*", High, "*", Single image
Data = 2 "No", "*", High, Maximum, "*"
Data = 2 "No", 'Highest availability', "*", "*", Single image
Data = 2 "No", 'Highest availability', "*", Maximum, "*"
Data = 2 "No", 'Highest availability', High, "*", "*"

```

25 In Table 4, an entry "\*" indicates that the effort level is independent of the answer to the associated question. Table 5 and 6 indicate the definition and decision table, respectively, for "GUI Complexity" rule group 140.

TABLE 5

```

[DefineBeginRuleGroup]
RuleGroupID = 30
RuleGroupName = "GUI complexity factor"
;
[DefineRule]
RuleName = "GUI complexity"
Priority = 100
Description = "GUI complexity"
THEN
    [#Effort_level] = "@matrix('GUI complexity', 'GUI
Reuse', 'Primary GUI dialogues')"
```

TABLE 6

```

[DefineMatrix]
MatrixID = 20
MatrixName = "GUI complexity"
MatrixCol = 2
Description = "GUI complexity"
50 Default = 1
#"GUI Reuse", "Primary GUI
dialogues"
Data = 4 "Less than 25%", 'More than 50'"
Data = 3 "Less than 25%", '25 to 50'"
Data = 2 "Less than 25%", '10 to 25'"
55 Data = 1 "Less than 25%", 'Less than 10'"
Data = 3 "25-50%", 'More than 50'"
Data = 2 "25-50%", '25 to 50'"
Data = 1 "25-50%", '10 to 25'"
Data = 1 "25-50%", 'Less than 10'"
Data = 2 "50-75%", 'More than 50'"
60 Data = 1 "50-75%", '25 to 50'"
Data = 1 "50-75%", '10 to 25'"
Data = 1 "50-75%", 'Less than 10'"
Data = 1 "75-100%", "*"

```

In the preferred embodiment, project estimator 100 comprises additional rule groups 140 relating to System Management, Security, Performance, Fault Tolerance, Mission Critical Application rule groups. Each of these quantify

different, implementation-dependent properties of the client/server system through a corresponding output EF. A summary of these rule groups 140 and the rules implemented for determining their corresponding effort factors is attached to this application as Appendix A.

EF serves as one component of a weighting factor that will be coupled to one or more task group neurodes 170 according to its relevance to the specific tasks represented by the neurode. For example, the user's responses to questions about the project displayed by advisor interface 110 may indicate that the project has an unusually low fault tolerance. This fact will be reflected in a correspondingly large EF when inference engine 130 applies fault tolerance rule group 140 to facts accumulated in memory working area 136. Consequently, any of task group neurodes 170 that relate to the stability of the client/server system against faults will require greater effort to complete and, consequently, will be strongly coupled to "fault tolerance" rule group 140.

Generally, the net impact of a property represented by a rule group 140 on one of task group neurodes 170 depends on both the EF of the rule group and the influence factor that reflects the correlation between task group 170 and the property at issue. This influence factor (IF) is implemented by rule-indirection interface 160 and operates on EF as a multiplicative factor. In the preferred embodiment of the invention, IF ranges between zero (no correlation between rule group 140 and task group neurode 170) and one (full correlation between rule group 140 and task group neurode 170).

Referring again to FIG. 3, the role of rule indirection interface 160 is indicated by the change in thickness of connecting line 144 as it passes from rule group 140 to task group neurode 170. In the disclosed example, the thickness of connecting line 144 above rule-indirection interface 160 indicates the relative size of EF for rule group 140, with thicker lines 144 indicating larger EFs. Reduction in EF by rule-indirection interface 160, i.e.  $IF < 1$ , indicates less than complete correlation between the plurality of tasks represented by task group neurode 170 and the system property represented by rule group 140.

For example, if task group neurode 170 represents a set of tasks relating to the GUI prototyping and rule group 140 relates to fault tolerance of a communication link, the correlation between fault tolerance rule group 140 and GUI prototyping task group 170 will be low ( $IF < 1$ ). The need for low fault tolerance will not have much impact on the tasks involved in prototyping the GUI. On the other hand, if task group neurode 170 represents a set of tasks relating to reliability of the client server system, rule-indirection interface 160 would likely maintain a strong correlation between rule group 140 and task group neurode 170, i.e.  $IF = 1$ .

Referring now to FIG. 4, there is shown a screen 400 representing the interplay between rule-indirection interface 160, task group neurodes 170 and rule groups 140. Window 410 displays task groups 170 that are used in the "DEFINE phase" of the client/server project. Labels 412 in window 410 represent one of task groups 170 necessary to define the project charter, analyze the current system, reengineer the business processes, and the like.

Window 420 on the right side of screen 400 indicates labels 422 of rule groups 140 linked to the highlighted task group neurode 170 (Define project charter). Linked rule groups 140 are those having non-zero IFs for "define project charter" task group neurode 170. A label 424 below window 420 indicates a component rule 142 of rule group 140, and below that is the EF (=1) determined from the user's responses by all component rules 142 of rule group 140. To

the left of EF in screen 400 there is also indicated an IF of 0.5, representing an intermediate correlation between "system management" 422 and "define project charter" 412. It is not surprising that there is some correlation here, since system management will have to be described in the project charter. Screen 400 displays similar correlations for each task group neurode 170 and each rule group 140 relevant to the client server system.

Referring again to FIG. 1, the last element of neural estimator 100 is summer 190, which collects the outputs from each of task group neurodes 170 to produce an estimate of the project effort (PE) at its output. Mathematically, this can be represented as follows:

$$PE = \sum_i B_i (EF_i IF_{ij})$$

Here,  $B_i$  is the baseline effort value for neurode 170(i),  $EF_i$  is the effort factor for rule group 140(j), and  $IF_{ij}$  is the influence factor coupling rule group 140(j) to task group 170(i). One summation is over all rule groups 140 correlated with a task group neurode 170 and the other summation is over all task group neurodes 170.

Referring now to FIG. 5, there is shown a flow chart of a method 500 for estimating the effort necessary to implement a client/server project in accordance with the present invention. Method 500 begins by assigning 520 a baseline effort value to each task group specified by the client/server architecture. Facts about the system requirements such as fault tolerance, security, performance, and capacity (size) are then collected 530 from a project manager or some other knowledgeable source. Expert-based rules 140 are then applied 540 to the collected facts to determine an effort factor (EF) for each rule group 140. For each rule group 140 and task group 170, a product of the corresponding effort factor and baseline effort value is scaled 550 according to an influence factor (IF) determined by the correlation between the rule group 140 and task group 170. The scaled products are then summed 560 to provide an estimate of the project effort (PE) required to complete the client/server project.

The present invention is made more powerful by the fact that it can be improved with use by allowing IF values generated by rule indirection module 160 to be modified according to difference between actual and estimated project efforts. For example, once a project has been completed, the actual project effort necessary to complete a task group 170 of the project can be compared with the project effort calculated for the task group by system 100. This project effort (PE) is given by  $\sum (B_i EF_i IF_{ij})$ , where the summation is over the j rule groups 140. Assuming that any difference between the actual and calculated (PE) value is attributable to rule-indirection module 160, the  $IF_{ij}$  values can be adjusted to improve agreement between the actual and calculated (PE) values.

Any of a number of well known algorithms may be used for training project estimator 100. One such method is "Minimum Error Learning Algorithm", as disclosed in Caudill & Butler, Understanding Neural Networks, Vol. 1, MIT Press.

Referring now to FIG. 6, there is shown a screen 600 in accordance with the preferred embodiment of the present invention for monitoring the accuracy of project estimator 100. Screen 600 allows a user to see the actual effort expended on a project, which in FIG. 6 corresponds to all task groups that make up the "DEFINE phase" of the project. As indicated, these task groups required 1.7 person months of effort to complete. Highlighting different labels

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610 displays either the actual effort required or the effort estimated by project estimator 100, depending on whether actual 620 or estimated 622 values are selected (upper right corner of screen 600). Actual efforts are entered into project estimator 100 by the user through a different interface. Using the algorithm identified above, actual values may be used to adjust IF values so that over time the performance of project estimator 100 improves.

**12**

It is understood that the embodiments discussed above are intended to be representative of the present invention, and persons skilled in the art will, based on this disclosure, be able to develop other systems and variations on systems that fall within the spirit of this invention. Accordingly, the present invention should be limited only by the following claims.

## Appendix A

RULE GROUP	RULE
Project size factor	IF [project size] = "Large" THEN [#Effort level] = 3  IF [project size] = "Normal" THEN [#Effort level] = 2  IF [project size] = "Small" THEN [#Effort level] = 1
System criticality factor	[#Effort_level] = @ matrix (system criticality, mission critical application , fault tolerance, performance, security, system management)
GUI complexity factor	[#Effort_level] = @ matrix (GUI complexity, GUI reuse, Primary GUI dialogues)
Application complexity factor	IF [business process reuse] = "25-50%" [complex business modules] = "more than 50" THEN [complex business modules] = "25-50"  IF [business process reuse] = "25-50%" [complex business modules] = "25-50" THEN [complex business modules] = "10-25"  IF [business process reuse] = "25-50%" [complex business modules] = "10-25" THEN [complex business modules] = "less than 10"  IF [business process reuse] = "50-75%" [complex business modules] = "more than 50" THEN [complex business modules] = "10-25"  IF [business process reuse] = "50-75%" [complex business modules] = "25-50" THEN [complex business modules] = "less than 10"  IF [business process reuse] = "50-75%" [complex business modules] = "more than 50" THEN [complex business modules] = "less than 10"  [#Effort level] = "@matrix ('Application complexity','Application process','complex business modules','external data feed','distributed processes)
Database transaction complexity factor	[#Effort_level] = @matrix (database transaction complexity, database transaction reuse, complex database transactions)

Database complexity factor	<p>IF [Database schema reuse] IN "25-50%, 50-75%" [Database stables] = "more than 500" THEN [Database tables] = "100-500"</p> <p>IF [Database schema reuse] IN "25-50%, 50-75%" [Database stables] = "100-500" THEN [Database tables] = "100-500"</p> <p>IF [Database schema reuse] = "75 - 100%" [Database stables] IN "more than 500, 100-500" THEN [Database tables] = "less than 100"</p> <p>[#Effort_level] = @matrix (database complexity, data relationship, database tables, distributed database)</p>
Legacy system complexity factor	[#Effort_level] = @ matrix (Legacy system complexity, obscure legacy system, legacy data elements)
Development environment stability factor	[#Effort_level] = @ matrix (Development environment stability, Development environment stability, Software stability, Hardware stability)
Development tool factor	<p>IF [Development tool] = "Third generation language" THEN [#Effort_level] = "3"</p> <p>IF [Development tool] = "GUI builder" THEN [#Effort_level] = "2"</p> <p>IF [Development tool] = "Fourth generation language" THEN [#Effort_level] = "2"</p> <p>IF [Development tool] = "CASE/Application generator" THEN [#Effort_level] = "1"</p>
Production environment stability factor	<p>[Hardware/Software stability] = @ matrix (Hardware/Software stability, Hardware stability, Software stability)</p> <p>[Network/Hardware expansion] = @ matrix (Network/Hardware expansion, Network expansion, Hardware expansion)</p> <p>[#Effort_level] = @ matrix (Production environment stability, Hardware/Software stability, Network/Hardware expansion)</p>
Management skill factor	<p>IF [Management experience] = "Inexperienced" THEN [#Effort_level] = "3"</p> <p>IF [Management experience] = "Moderately experienced" THEN [#Effort_level] = "2"</p> <p>IF [Management experience] = "Highly experienced" THEN [#Effort_level] = "1"</p>
Project team prior experience factor	[#Effort_level] = @ matrix (Project team prior experience, Working together, Project team experience, Development environment familiarity)

Project team skill factor	{#Effort_level} = @ matrix (Project team skill factor, Project team skill, Development tool experience)
Documentation expertise factor	IF [Documentation expertise] = "High" THEN [#Effort_level] = "1"  IF [Documentation expertise] = "Moderate" THEN [#Effort_level] = "2"  IF [Documentation expertise] = "Low" THEN [#Effort_level] = "3"
Coding Experience Factor	IF [Coding expertise] = "High" THEN [#Effort_level] = "1"  IF [Coding expertise] = "Moderate" THEN [#Effort_level] = "2"  IF [Coding expertise] = "Low" THEN [#Effort_level] = "3"
Modeling experience factor	IF [Modeling expertise] = "High" THEN [#Effort_level] = "1"  IF [Modeling expertise] = "Moderate" THEN [#Effort_level] = "2"  IF [Modeling expertise] = "Low" THEN [#Effort_level] = "3"
Staffing factor	IF [Full time staff] = "Less than 15" THEN [#Effort_level] = "4"  IF [Full time staff] = "15-49" THEN [#Effort_level] = "3"  IF [Full time staff] = "50-100" THEN [#Effort_level] = "2"  IF [Full time staff] = "Over 100" THEN [#Effort_level] = "1"
User participation factor	IF [User participation] = "No participation" THEN [#Effort_level] = "3"  IF [User participation] = "Moderate" THEN [#Effort_level] = "2"  IF [User participation] = "Significant" THEN [#Effort_level] = "1"

User requirement volatility factor	IF [User requirement changes] = "Significant" THEN [#Effort_level] = "3"  IF [User requirement changes] = "Moderate" THEN [#Effort_level] = "2"  IF [User requirement changes] = "Minor" THEN [#Effort_level] = "1"
Centralized design approval factor	IF [Centralized design approval] = "yes" THEN [#Effort_level] = "2"  IF [Centralized design approval] = "No" THEN [#Effort_level] = "1"
Prototype/full implementation factor	IF [Implementation] = "Full implementation" THEN [#Effort_level] = "3"  IF [Implementation] = "Incremental implementation" THEN [#Effort_level] = "2"  IF [Implementation] = "Prototype" THEN [#Effort_level] = "1"
Prototyping approach factor	IF [Prototype application] = "No" THEN [#Effort_level] = "2"  IF [Prototype application] = "Yes" THEN [#Effort_level] = "1"
Corporate politics factor	IF [Political delay] = "High" THEN [#Effort_level] = "3"  IF [Political delay] = "Moderate" THEN [#Effort_level] = "2"  IF [Political delay] = "Low" THEN [#Effort_level] = "1"



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## Appendix B

Define project charter  
 Define high level functional objectives  
 Define high level management objectives  
 Identify champion users  
 Conduct initial feasibility study  
 Conduct initial risk analysis  
 Conduct initial cost/benefit analysis  
 Create a project charter document  
 Obtain upper management and user buy-in and commitment  
 Deliverable: Project Charter document

Analyze current system  
 Review documentation on current system  
 Review current system's architecture  
 Identify current users and their tasks  
 Gather user feedback on the current system  
 Identify current system's developers  
 Gather developers' feedback on the current system  
 Identify current system's administrators  
 Gather the system's administrators' feedback on the current system  
 Identify shortcomings of current system  
 Create a current system analysis document  
 Deliverable: Current System Analysis document

Reengineer business processes  
 Identify the reengineering team  
 Select a business process reengineering tool  
 Conduct reengineering workshops  
 Define critical business success factors  
 Model existing business processes  
 Reengineer business processes  
 Identify key enabling technology  
 Revise feasibility study  
 Revise risk analysis  
 Revise cost/benefit analysis  
 Write first-draft reengineering document  
 Distribute reengineering document for review  
 Obtain reengineer sign-off  
 Deliverable: Reengineered Business Process Design document

Conduct JRP workshop  
 Identify JRP team members  
 Select a JRP leader  
 Schedule JRP workshops  
 Prepare JRP agenda and presentation material  
 Distribute JRP agenda and presentation material  
 Distribute project documents to JRP members  
 Conduct JRP workshops  
 Define major system functionalities  
 Prioritize system functionalities  
 Identify interfaces to external systems  
 Identify users and roles of the system  
 Identify user interface requirements  
 Identify user task requirements  
 Identify performance requirements  
 Identify fault tolerance requirements  
 Review corporate security standards  
 Identify security requirements  
 Identify system management requirements  
 Identify batch processing requirements  
 Identify storage requirements  
 Identify on-line help requirements  
 Identify help-desk requirements  
 Identify end-user training requirements  
 Identify corporate wide policy and standards  
 Resolve all open issues  
 Consolidate workshop results, create a project requirement document  
 Distribute the requirement document for review  
 Revise requirement document  
 Obtain requirement document sign-off  
 Obtain project requirements sign-off  
 Deliverable: Project Requirement Specification document

Define system architecture  
 Identify potential system architectures

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Analyze potential system architectures  
 Determine application partitioning  
   Define presentation service layer  
   Define presentation logic layer  
   Define business rule layer  
   Define database request layer  
   Define database service layer  
 Determine data replication strategy  
 Define production hardware and software environment  
 Select a system architecture  
 Review and modify project tasks  
 Deliverable: System Architecture Definition document  
 Define the Data Warehouse  
   Identify need for data warehouse  
   Evaluate the industry's standard data warehouse types  
   Select data warehouse client/server architecture  
   Deliverable: Data Warehouse Requirements Document  
 Research data warehouse vendors  
   Create a list of data warehouse providers  
   Research data warehouse software alternatives  
   Research data warehouse hardware alternatives  
   Select "physical" or "virtual" data warehouse  
   Contact the data warehousing vendors  
   Review marketing materials and seek additional information  
   Select vendors to receive RFI  
   Deliverable: RFI Document  
 Research package vendors  
   Create a list of package providers  
   Contact the vendors  
   Review marketing materials and seek additional information  
   Select vendors to receive RFI  
   Deliverable: RFI Document  
   Deliverable: Package Vendor Research Document  
 Select vendor package  
   Read and analyze responses to RFI  
   Invite vendors for in-house demos  
   Review vendor demos  
   Perform hands-on evaluation  
     Compare project specification to vendor feature list  
     Evaluate architectural constraints of package  
     Evaluate database constraints of package  
     Evaluate interprocess constraints of package  
     Grade the usability of the GUI  
     Grade the package's stability  
   Perform final analysis of vendor's viability  
   Select a package  
   Deliverable: Package Evaluation & Selection Report  
 Define the integrated package  
   Define the package application areas  
   Define the package environment  
     Define the package hardware environment  
     Define the package software environment  
     Define the package database environment  
     Look for hidden incompatibilities  
   Define the package system architecture  
   Define the package integration points  
   Define the package tool suite  
   Define the package system management interfaces  
   Deliverable: Package Integration Definition Document  
 Review project definition process  
   Conduct definition process review session  
   Refine the project definition process  
   Deliverable: Process Review document  
 Customize the CS/8000 project plan  
   Confirm project tasks and deliverables  
   Define timeboxes if needed  
   Define project iterations  
   Review prioritized system functions  
   Assign highest priority tasks to the initial iterations  
   Define project partitions  
   Define project teams

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Customize project tasks  
 Plan the project resources  
 Identify resource requirements  
 Assess resource skills and training requirements  
 Identify the need for outside consultants  
 Hire outside consultants if needed  
 Schedule required resource training  
 Assign resources to teams  
 Assign resources/teams to tasks  
 Assemble the final project plan  
 Develop quality plan  
 Develop estimates and schedule  
 Create a project plan prototype  
 Distribute project plan for review  
 Consolidate feedback and revise project plan  
 Obtain project plan sign-off  
 Deliverable: Project Plan document  
 Establish project control  
 Establish project status reporting procedures  
 Establish issues tracking and resolution methods and tools  
 Establish cost and schedule tracking methods  
 Establish performance and quality classifications  
 Deliverable: Project Control Plan and Procedures document  
 Create a Request For Proposal, if desired  
 Determine the precise requirements which will be addressed in the RFP  
 Evaluate the benefits associated with the RFP  
 Evaluate the risks associated with the RFP  
 Deliverable: Request for Proposal document  
 Implement CASE/Repository  
 Confirm the commitment to a CASE/Repository approach  
 Evaluate and select a CASE/Repository  
 Procure the CASE/Repository  
 Procure the additional necessary hardware and software  
 Establish training schedule and objectives  
 Install the CASE/Repository  
 Train staff on the CASE/Repository  
 Designate a staff as the CASE/Repository manager  
 Customize the CASE/Repository  
 Establish procedures and guidelines for using the CASE/Repository  
 Deliverable: Installed CASE/Repository environment and CASE/Repository document  
 Implement JAD workshops  
 Select JAD design and documentation tools  
 Identify JAD team members  
 Select a JAD leader  
 Schedule JAD workshops  
 Prepare JAD agenda and presentation material  
 Distribute JAD agenda and presentation material  
 Distribute project documents to JAD members  
 Conduct JAD workshop  
 Conduct system modeling  
 Identify corporate business rules  
 Resolve all open issues  
 Consolidate workshop results and create a JAD design document  
 Distribute the JAD document for review  
 Revise JAD design document  
 Obtain JAD design sign-off  
 Deliverable: Project Design document  
 Model system context  
 Define the interaction between the system and organizational units  
 Define the interaction between the new system and existing system  
 Define the major data flows in and out of the system  
 Deliverable: System Context Model and System Context Model document  
 Model user tasks, events, and workflow  
 Understand who the primary users of the system are  
 Classify users into functional roles  
 For each role, identify user tasks and the frequency of each task  
 For each role, identify events that triggers the tasks  
 Analyze task dependencies and interactions  
 Identify inputs and outputs for each task  
 Analyze the flow of work and data among users  
 Deliverable: User Task Analysis document

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#### Model user interface

- Select a tool for modeling user interface
- Understand user roles and tasks associated with each role
- For each set of related tasks, define one or more user screens
- Define the screen flow based on task flow analysis
- Define the events and processing for each screen
- For each screen, build a 'look and feel' model
- Link the screen models to create a minimal prototype
- Obtain reporting requirements from users
- Create report models
- Conduct review session with users
- Refine screen and report designs
- Obtain user sign-off
- Deliverable: Completed User Interface Model and User Interface Model document

#### Model objects

- Identify major classes and objects
- Structure classes and objects into hierarchies
- Identify relationships between classes and objects
- Identify attributes for classes and objects
- Identify object states and behavior
- Define object services (methods)
- Deliverable: Object Analysis Model and Object Analysis document

#### Model business events

- Identify major business events
- For each event, describe the process that need to happen
- Deliverable: Business Event Model and Business Event document

#### Model business processes

- Identify major business processes of the system
- Decompose each process into subprocesses
- Define the dependency and relationship among processes
- Identify data input/output for each process
- Deliverable: Data/Process Flow Model and Data/Process Flow document

#### Model business functions

- Identify major business functions of the system
- Decompose each function into subfunctions
- Deliverable: Function Decomposition Model and Function Decomposition document

#### Model the data

- Select a functional area to model
- For each area, identify major data elements
- Build a dictionary of data elements and their descriptions
- Group elements into entities
- For each entity, define a unique identifier (key)
- Estimate the data volume (cardinality) for each entity
- Analyze and model relationships among entities
- Add attributes to entities
- Normalize the data model
- Combine data models from all functional areas
- Deliverable: Data Model and Data Model document

#### Model the distributed system

- Identify geographic locations where the system will operate
- Analyze processes distribution for each location
- Analyze data distribution for each location
- Analyze function distribution for each location
- Analyze event distribution for each location
- Analyze object distribution for each location
- Update the system models with the distributed analysis
- Deliverable: Distributed System Model and Distributed System Model document

#### Model the Data Warehouse

- Identify operational data to be aggregated
- Design the data aggregation mechanism
- Design the summarization criteria
- Design the data access mechanism
- Deliverable: Data Warehouse Model Document

#### Model the integrated package

- Model the package application areas
- Model the package environment
  - Model the package hardware environment
  - Model the package software environment
  - Model the package database environment
- Model the package system architecture
- Model the package integration points

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Model the package tool suite  
 Model the package system management interfaces  
 Deliverable: Package Integration Model Document

Refine system models  
 Review all system models  
 Iteratively refine the system models  
 Deliverable: Refined System Models and Refined System Model document

Plan for system fault-tolerance  
 Review system fault-tolerance requirements  
 Analyze the planned system for potential failure points  
 Discover and select vendor's high availability solutions  
 Procure the required hardware and software solution  
 Create a system fault-tolerance test plan  
 Deliverable: System Fault-Tolerance Plan document

Plan the network  
 Conduct network planning sessions  
 Review existing network architecture  
 Define/review enterprise computing strategy and goal  
 Analyze the performance requirements of the network  
 Analyze the fault tolerance requirements of the network  
 Analyze the security requirements of the network  
 Analyze the system management requirements of the network  
 Analyze the system integration requirements of the network  
 Analyze the open system requirements of the network  
 Design the network architecture  
 Evaluate and prototype vendor solutions  
 Create a network architecture implementation plan  
 Prototype the network architecture  
 Implement the network architecture  
 Deliverable: Network Architecture document

Plan the database servers  
 Analyze the performance requirements of the database server  
 Analyze the fault tolerance requirements of the database server  
 Analyze the security requirements of the database server  
 Analyze the system management requirements of the database server  
 Analyze the system integration requirements of the database server  
 Analyze the open system requirements of the database server  
 Analyze the data replication requirements of the database server  
 Evaluate hardware vendor solutions  
 Evaluate operating system vendor solutions  
 Evaluate database software vendor solutions  
 Conduct database server capacity planning  
 Select a database server hardware platform  
 Select a database server operating system platform  
 Select database server software  
 Procure the required hardware and software  
 Install the hardware and software  
 Deliverable: Installed database servers and Database Server document

Plan client workstation environment  
 Define client hardware platform  
 Define client OS platform  
 Select client development tool(s)  
 Procure the required hardware and software  
 Install the hardware and software  
 Deliverable: Installed client workstations and Client Workstation document

Plan development environment  
 Analyze the requirement for physical development environment  
 Analyze the existing physical environment  
 Determine the hardware and software resources required for development  
 Procure the required hardware and software  
 Establish training schedule and objective  
 Install hardware and software  
 Train staff on the hardware and software  
 Setup environment for source code control  
 Designate a staff member as the source code librarian  
 Establish source code backup procedure  
 Deliverable: Installed development environment and Development Environment document

Plan database environment  
 Designate a database administrator responsible to the project  
 Define database standards  
 Establish procedures for requesting database changes

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Establish procedures for reviewing and optimizing transactions  
 Establish procedures to manage multiple test database instances  
 Establish procedures for migrating database from development to test environment  
 Establish procedures for migrating database from test to production  
 Deliverable: Database Implementation and Migration Plan document

Plan the test environment  
 Identify testing objectives  
 Define procedures for problem tracking and resolution  
 Determine the hardware and software resources required for testing  
 Procure required hardware and software  
 Establish training schedule and objective  
 Install hardware and software  
 Train staff on the hardware and software  
 Setup environment and staff for configuration management  
 Develop test plans for unit, usability, system integration, and security testing  
 Deliverable: Installed test environment and Test Plan documents

Plan the production environment  
 For multi-site system, select a site for the initial pilot system  
 Determine strategy for phasing in the new system  
 Determine the production hardware and software purchase plan  
 Determine the production software strategy  
 Establish system management strategy  
 Establish performance monitoring procedures  
 Establish end-user feedback procedures  
 Determine help desk requirements  
 Select help desk staff  
 Train help desk staff  
 Deliverable: Production Transition Plan document

Create application development standards and guidelines  
 Plan for reusability  
 Identify what new application objects will be reusable for future projects  
 Identify what existing application objects, if any, can be reused for this project  
 Define GUI standards  
 Define GUI presentation model  
 Establish GUI performance guidelines  
 Establish database access performance guidelines  
 Define coding standards  
 Deliverable: Application Development Plan document

Plan data conversion  
 Analyze the data conversion requirements  
 Analyze the conversion data for integrity and volume  
 Evaluate vendor-specific data conversion software  
 Define the data conversion strategy  
 Determine the method for running the data conversion in batch mode  
 Deliverable: Data Conversion Plan document

Determine data analysis components  
 Analyze the need for data analysis and mining  
 Evaluate vendor-specific data analysis and mining tools  
 Gather test data for the data analysis and mining tools  
 Run test data against each data analysis and mining tools  
 Select a data analysis and mining tool  
 Deliverable: Data Analysis Plan document

Create system management plan  
 Review system management requirement document  
 Evaluate vendor-specific system monitoring and automation tools  
 Select system monitoring and automation tools  
 Deliverable: System Management Plan document

Review project planning process  
 Conduct planning process review session  
 Refine the project planning process  
 Deliverable: Process Review document

Create GUI prototype  
 Select GUI prototyping tool  
 Design a GUI prototype  
 Build a GUI prototype  
 Conduct GUI prototype review session  
 Obtain sign-off for the GUI prototype  
 Deliverable: GUI prototype and GUI Prototype document

Develop performance prototype  
 Identify areas of performance concern  
 Determine performance prototyping method

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Build a performance prototype  
Run the performance prototype  
Tune the performance prototype  
Re-run the performance prototype  
Conduct performance prototype review session  
Address critical performance issues  
Update system design documents  
Deliverable: Performance prototype and Performance Prototype document

Create feasibility prototype  
Identify areas of new/untested technology  
Build a feasibility prototype  
Run the feasibility prototype under stress  
Conduct feasibility prototype review session  
Address critical issues  
Deliverable: Feasibility prototype and Feasibility Prototype document

Create data warehouse prototype  
Scope the data warehouse prototype  
Determine warehouse prototyping method  
Build the warehouse prototype  
Build the prototype warehouse data propagation method  
Build the prototype warehouse data aggregation method  
Build the prototype warehouse data analysis method  
Build the prototype warehouse end-user query methods  
Run the warehouse prototype  
Conduct warehouse prototype review sessions  
Address critical issues  
Update system design documents  
Deliverable: Warehouse Prototype document

Create package integration prototype  
Scope the package prototype  
Determine package prototyping method  
Build the package prototype  
Run the package prototype  
Develop prototype scripts  
Run the prototype scripts  
Conduct package prototype review sessions  
Address critical issues  
Update system design documents  
Deliverable: Package Prototype document

Review prototyping process  
Conduct prototype process review session  
Refine the prototyping process  
Deliverable: Process Review document

Perform package integration verification  
Verify package database connectivity  
Verify database transactions  
Verify feeds and speeds  
Verify functionality of integration points  
Verify tool suite  
Verify system management interfaces  
Verify GUI usability  
Verify data conversion capabilities  
Deliverable: Package Verification and Package Implementation Verification document

Integrate vendor package  
Implement package database connectivity  
Implement database transactions  
Configure package feeds  
Configure package integration points  
Develop batch programs  
Start up system management monitors  
Perform data conversions  
Verify data conversion capabilities  
Deliverable: Package Integration and Package Integration document

Build physical database  
Convert data model to physical database design  
Review data model  
Review database standards  
Map entities to tables  
Map attributes to table columns  
Add application-specific parameter tables to the database  
Define column-level data integrity rules

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Define referential integrity rules  
 Define physical storage parameters for the tables  
 Define database replication  
 Optimize database design for performance  
 Identify frequent and time-critical transactions  
 Define indexes to optimize retrieval  
 If necessary, denormalize table to optimize transactions  
 Distribute tables and indexes across disk volumes to balance I/O loads  
 Generate database definition language and load database  
 Setup database replication mechanism  
 Setup database security  
 Setup test data for the developers  
 Deliverable: Installed physical database and Physical Database document  
 Implement the database transactions  
 Define database transactions  
 Prioritize the transactions in order of importance  
 Review database access performance guidelines  
 Code database transactions  
 Optimize the transactions  
 Deliverable: Completed database transactions and Database Transactions document  
 Build reusable business objects  
 Review coding standards  
 Review corporate business processes to be automated  
 Review object analysis model  
 Define requirements for reusable business objects  
 Build reusable business object classes  
 Refine reusable business object classes  
 Optimize reusable business object classes for performance  
 Deliverable: Complete the reusable business objects and the Business Object Document.  
 Code the business logic  
 Review coding standards  
 Review corporate business rule document  
 Implement corporate business rules as server level rules and stored procedures  
 Review data flow diagram  
 Map processes to application procedures  
 Confirm that all processes are mapped to application procedures  
 Code application procedures  
 Implement application-level security if necessary  
 Deliverable: Completed business logic code and Business Logic document  
 Customize the package data structures  
 Select a database customization strategy  
 Review corporate business rule document  
 Customize the package's data structures on the server  
 Review ER diagram  
 Customize the data structures on the client or application side  
 Re-implement package security if necessary  
 Deliverable: Customized package data structures and Package Data Structures document  
 Customize the package business logic  
 Select a package customization strategy  
 Review corporate business rule document  
 Customize the package's business logic at the server level  
 Implement corporate business rules as server level integrity and stored procedures  
 Review data flow diagram  
 Map processes to application procedures  
 Confirm that all processes are mapped to application procedures  
 Customize the business logic on the client or application side  
 Re-implement package security if necessary  
 Deliverable: Customized package business logic code and Package Business Logic document  
 Build reusable GUI objects  
 Define standards for reusable GUI objects  
 Review user interface model and identify candidates for reuse  
 Build reusable GUI objects  
 Refine reusable GUI object classes  
 Optimize reusable object classes for performance  
 Deliverable: Complete the reusable GUI objects and the GUI Object Document  
 Develop GUI Interface  
 Review GUI interface standards  
 Review GUI presentation model  
 Review GUI performance guidelines  
 Review GUI screen prototypes  
 Review security requirements



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Review user task analysis document  
 Model screen flow from process flow model  
 Build GUI interface  
 Implement GUI level security if necessary  
 Optimize GUI interface for performance  
 Design reports  
 Write reports  
 Deliverable: Completed GUI Interface code and GUI Interface document

Build data warehouse monitor  
 Review GUI interface standards  
 Select activities to monitor  
 Review GUI performance guidelines  
 Review GUI screen prototypes  
 Review security requirements  
 Verify the operational data to be moved into the data warehouse  
 Finalize the user interface  
 Build GUI interface  
 Implement GUI level security if necessary  
 Optimize GUI interface for performance  
 Finalize design of reports  
 Write reports  
 Deliverable: Completed Data Warehouse Monitor

Implement data conversion  
 Define data mapping between the legacy data and the relational data  
 Check the legacy data for integrity or missing information  
 Resolve data integrity issues  
 Code data conversion procedures  
 Setup batch programs to automate execution of the conversion procedures  
 Deliverable: Completed data conversion and Data Conversion document

Create on-line help  
 Review On-line Help requirements  
 Determine methods of presentation  
 Define Help topics and contents  
 Code On-line Help facility  
 Build Help glossary  
 Deliverable: Completed On-line Help and On-line Help document

Create batch processes  
 Review batch processing requirements  
 Setup required software component for batch processing  
 Partition jobs into related groups  
 Define job dependencies among job groups  
 Setup batch jobs  
 Test and monitor batch jobs  
 Deliverable: Completed batch processing code and Batch Processing document

Implement production support  
 Develop user documentation  
 Train users on the system  
 Develop operation manual  
 Develop application maintenance manual  
 Setup help desk service  
 Deliverable: Production support implemented and Production Support document

Perform unit testing  
 Test GUI interface  
 Test business logic  
 Test database integrity  
 Deliverable: Completed Unit Testing and Unit Test Results document

Perform usability testing  
 Setup a usability testing lab  
 Select test candidates  
 Conduct usability tests  
 Review results and user feedback  
 Modify application based on usability test results  
 Deliverable: Completed Usability Testing and Usability Test Results document

Perform system fault-tolerance testing  
 Review system fault-tolerance test plan  
 Perform system fault-tolerance test  
 Deliverable: Completed System Fault-Tolerance test

Perform system integration testing  
 Conduct test plan review session  
 Develop integration test code and data  
 Perform System Integration Testing

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Review test results with the development team  
 Deliverable: Completed System Integration Testing and Integration Test Results document  
 Perform security testing  
 Conduct test plan review session  
 Perform security test  
 Review test results with the development team  
 Test system fault-tolerance  
 Test overall reliability of system security  
 Deliverable: Completed System Security Testing and System Security Test Results document  
 Implement the production environment  
 Setup production hardware and software  
 Setup production database  
 Migrate legacy data  
 Install application  
 Implement database security  
 Implement network security  
 Implement performance monitoring procedures  
 Cutover to the new system  
 Run existing system in parallel until the new system is stable  
 Validate the new system  
 Complete cutover - shutdown old system  
 Deliverable: Fully implemented system and Production Implementation document  
 Perform ROI analysis  
 Analyze completed project against stated goals  
 Determine actual benefits against planned benefits  
 Determine actual costs against estimated costs  
 Deliverable: Completed ROI analysis and Return On Investment document  
 Review implementation process  
 Conduct implementation process review session  
 Refine the implementation process  
 Deliverable: Process Review document

We claim:

1. A method for estimating an effort required to implement a client/server system having user-specified properties, the method comprising the steps of:
  - associating a plurality of related tasks into a one of a plurality of task groups;
  - defining a neural network having a plurality of neurodes, each neurode associated with one of said task groups;
  - assigning a baseline effort value to each task group;
  - receiving system information, from a user, relating to the user-specified properties of the client/server system;
  - applying rule groups of an expert system to the system information to determine an effort factor with each user-specified property, said effort factor representing the potential impact of each user-specified property on each of said task groups;
  - automatically determining a plurality of influence factors, each influence factor representing a correlation between one of said rule groups and one of said task groups;
  - determining a task group value for each task group based upon said baseline value associated with each task group, said effort factors, and said influence factors, said task group value representing an estimate of the effort required to perform the tasks in each task group; and
  - combining said task group values to generate a system estimation value representing an estimate of the effort required to implement a client/server system having user-specified properties.
2. A system for estimating an effort required to implement, using task groups, a client/server system having user-specified properties, the system comprising:
  - an advisor interface module;
  - an inference engine;
  - a question module coupled to the advisor interface module for eliciting system information from a user about the user-specified properties and making it available to the inference engine;
  - a plurality of rule groups, each rule group disposed to receive signals from said inference engine and said question module, comprising a plurality of related rules, for estimating an effort factor for each rule group based upon a relationship between each rule group and the user-specified properties of the client/server system when one or more rules of each rule group is applied to the system information by the inference engine;
  - a network of neural nodes, each neural node being associated with one of the task groups, each task group including a one or more related tasks for implementing the client/server system;
  - a rule indirection module, coupled to the neurodes and the rule group, for coupling the effort factor of each rule group to each neurode according to an influence factor, said influence factor representing a correlation between each rule group and each task group; and
  - a task group combination unit, coupled to said task groups and said rule indirection module, for combining a value

- associated with each neural node representing an estimate of an effort for completing the tasks of each task group based upon a baseline effort value, said effort factors and said influence factors, to generate an estimated effort value representing an estimation of the effort required to implement the client/server system.
3. The method of claim 1, further comprising the steps of:
  - receiving an actual effort value representing an actual effort expended to implement the client/server system; and
  - adjusting said influence factor according to a difference between said actual effort value and said system estimation value.
4. The system of claim 2, further comprising a memory working area coupled to the question module and the inference engine, for storing the elicited system information and making it available to the inference engine.
5. The system of claim 2, further comprising a question rulebase coupled to the inference engine and the question module, for selecting questions for display to the user according to system information received from the user.
6. A method for estimating an effort required to implement a client/server system having user-specified properties, using a plurality of task groups, a plurality of rule groups associated with user-specified properties, and an inference engine, the method comprising the steps of:
  - associating a plurality of related tasks into a one of the plurality of task groups;
  - defining a neural network having a plurality of neurodes, each neurode associated with one of said task groups;
  - assigning a baseline effort value to each task group;
  - collecting system information about the user-specified properties;
  - applying the rule groups to the system information to associate an effort factor with the system information;
  - determining a product of the effort factor, associated with the system information, and the baseline effort value, associated with the task group; and
  - scaling the product by an influence factor representing a correlation between the user-specified property and the task group to produce a scaled product.
7. The method of claim 6, further comprising the steps of:
  - receiving an actual effort value representing an actual effort expended to implement the client/server system; and
  - adjusting the influence factor to reflect a difference between said actual effort value and the estimated effort value.
8. The system of claim 2, further comprising:
  - an adjusting unit, coupled to said rule indirection module, for receiving an actual effort value representing an actual effort for implementing the client/server system, and for modifying said influence factors based upon a difference between said actual effort value and said estimated effort value.

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